Universidad Carlos III de Madrid

OO/UC3M/53- INFRARED (IR) REMOTE SENSING OF GASES

The IR Imaging and Remote Sensing Laboratory – **LIR-UC3M** of Universidad Carlos III, has developed Multi and Hyper spectral IR analysis techniques for gas remote sensing. Design of specific sensors for the determination of gases and their concentration are proposed. Almost all gases (CO_2, CO, NO_2, O_3, HC o NH); related to industrial, environmental or military safety can be detected.
Companies or centres with interest in the use of specific application sensors are required.

Description and special features

LIR-UC3M possesses the necessary instruments and scientific capabilities for the development of specific gas sensors. Particular techniques have been developed for the detection of CO_2, CO, SO_2, NO_2, NO, O_3, and gases with HC or NH bonds, etc.

Definitely, all gases of polar molecules emit and absorb in clearly differentiated (on their spectrum) and characteristic IR wavelengths that distinguish them from any other: two gases will have the same spectrum only if they have the same composition. Besides, the emission or absorption spectrum provides characteristic information of other important aspects of the gas such as concentration or temperature. LIR possesses instruments based on multi and hyper spectral sensors, Imaging and FTIR spectroradiometers that allow for a detailed analysis of the specific spectral characteristics to detect a gas in relation to the rest of emissions from the scene on the basis of the present IR radiation background. From this survey, LIR has the capacity to design specific sensors, generally with few bands, adapted to each problem.

The design of a sensor for the remote detection of a gas or a given mixture of gases asks for the study of the radiation characteristics of the IR scene, not only of the gas or gases in question but most and foremost, of the IR or typical background where the gas is to be found and which will mask its detection. This analysis must be carried out on high spatial and spectral resolution in order to establish the characteristics that define the minimum number of work bands of the sensor and the necessary processing for an optimal detection.

On the other hand, the short response time of current IR sensors, including the imaging ones, allows for real time analysis of fast phenomena. Likewise, multi and hyper spectral analysis allows these sensors the use of redundancy on the detection which dramatically reduces the probability of false alarms (PFA) and increases the detection probability (PD) in relation to the current ones. These properties make them specially useful on process control and safety applications, for this reason, they are becoming common on systems demanding special capabilities, such as military or Aerospatiale, where they are superseding current single band sensors. In a few years, in view of the cost decrease, a massive appearance of multi or hyper spectral IR sensors can be expected even on classical industrial applications.

For the analysis of a typical scene, LIR possesses specific instrumentation such as multispectral IR cameras in the bands of 3-5 and 8-12 microns, spectroradiometers for the entire IR spectrum (2-16 microns), as well as hyperspectral imaging systems for different IR regions. Nowadays LIR is a National University Laboratory with a unique capacity for the spectral analysis of the IR scene.

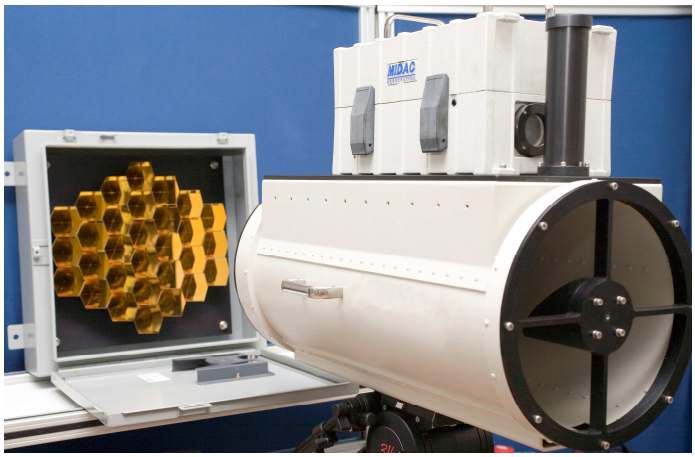

Fig. 1. High resolution FTIR spectroradiometer (2-16 μm) on a Newtonian telescope and retroreflector

Fig. 2. High performance camera and detail of multispectral system on the mid IR (3-5 μm)

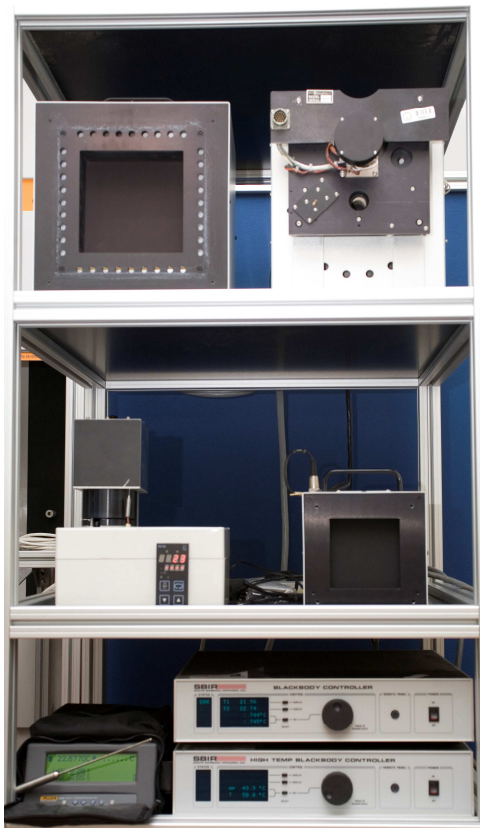

Fig. 3. High performance extensive and cavity black bodies for calibrating spectroradiometers and IR imaging systems in a wide temperature range.

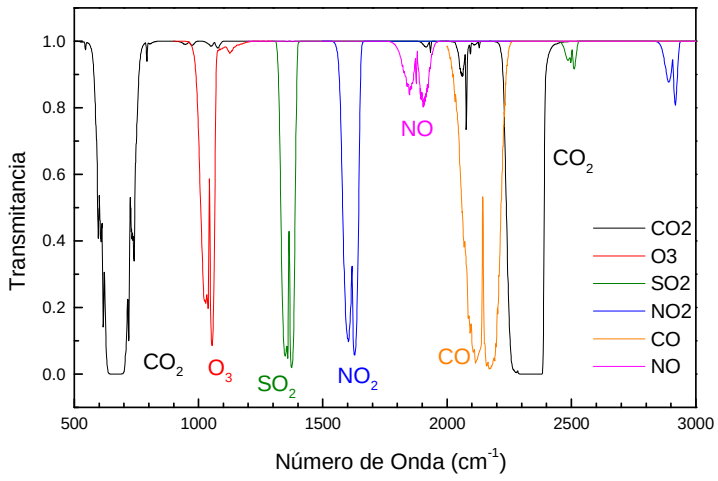

Fig. 4. Absorption spectrum of gases of environmental interest on the infrared from 3.3 to 20 μm (3000-500 cm^{-1})

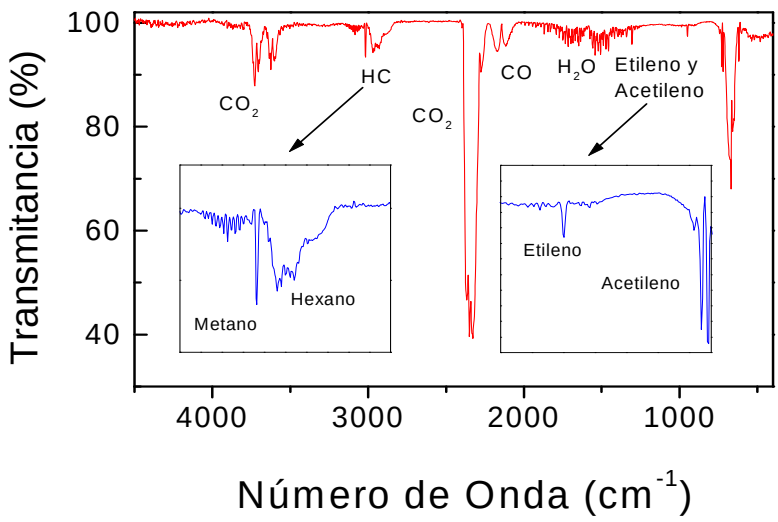

Fig. 5. Typical vehicle exhaust fumes and detail of minority components obtained by FTIR spectroradiomety

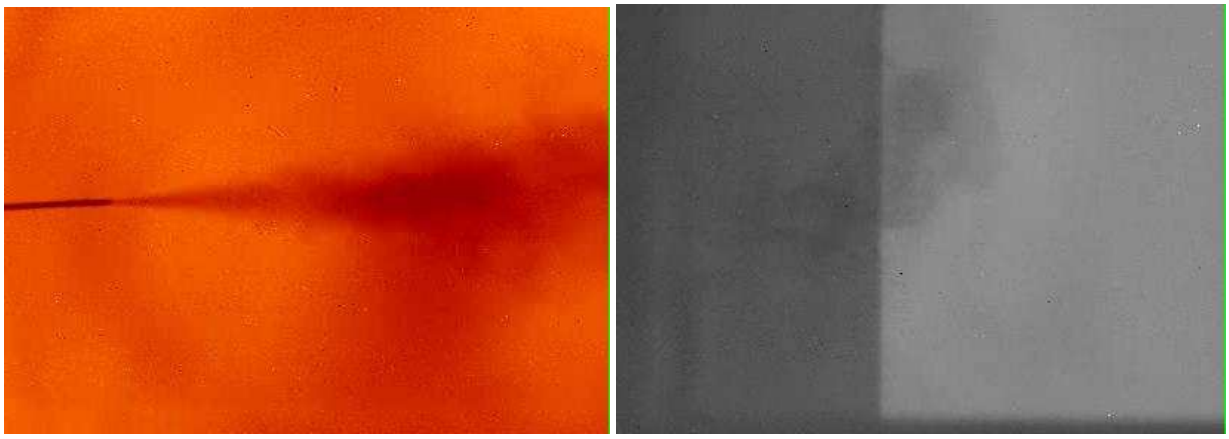

Fig. 6. Detection of “invisible” toxic gas clouds through infrared spectral imaging.

Innovative aspects
The majority of current IR sensors are single band. They analyse the whole energy received from the object in that band, however they are not able to measure the spectral distribution, limiting the acquisition of quantitative data. The new IR sensors technology permits multi or hyperspectral sensing multiplying the capability for gas composition and quantitative gas analysis.

Competitive advantages
It will increase competitiveness of the purchasing companies by providing a very reliable system of remote gas sensing for those working in sectors such as fuel, chemical, energy, in NBQ applications (remote

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Competitive advantages
sensing of toxic clouds), perimeter security for gases, etc

Technology Keywords
Hyperspectral sensors; multispectral sensors; hyper and multi spectral processing; spectral and spatial processing; IR cameras; IR passive sensors; IR gas signature; Sensors / Multisensor Technology, Instrumentation; Optical technology related to measurements; Sensor Technology related to measurements

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